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THE SOUTHERN CORN ROOTWORM AND FARM PRACTICES TO CONTROL IT

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OF ALL CORN PESTS in the South one of the most serious is the larva, or young, of the 12-spotted cucumber beetle—the so-called southern corn rootworm. True to its name, it feeds on the roots, but in young corn it also drills a small hole in the stem just above the first circle of roots, boring out the crown and killing the bud. Attacked plants either die outright or are so badly stunted as to be unproductive. Lowland corn suffers the most and injury is greatest during cool, damp seasons. The adult, or beetle, is also exceedingly destructive; not, however, to corn, but to cucumber, squash, and a great variety of other truck crops and ornamental plants.

Progressive farming methods, as described in this bulletin, will reduce the ravages of this insect. Burn over waste places to destroy dead grass, weeds, and rubbish in which the beetles winter. If possible, avoid planting corn in fields which contained corn the year before. Enrich the soil by planting legumes so that the corn will have a better chance of recovering from rootworm injury. Protect the bobwhite. This bird destroys many beetles of the rootworm. Plant corn late enough to avoid serious injury from rootworms, as recommended on page 10 of this bulletin.

Contribution from the Bureau of Entomology

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ECONOMIC IMPORTANCE AND COMMON NAMES.

CORN GROWERS in the Southern States suffer damage from the southern corn rootworm (fig. 1) practically every year. In fact, as a serious corn pest in the South the rootworm has few competitors. During some seasons it is quite a difficult matter to get a stand of corn in the lowlands on account of these worms. During years of heavy infestation it is necessary to replant corn as many as three times, and even then only a poor stand is obtained. The loss that may be attributed to the ravages of the pest is probably even greater and more far-reaching than is commonly supposed. Very often weather conditions are blamed for the yellowish and sickly appearance of corn and the resulting poor yield of the crop when the true cause is southern corn rootworm injury.



FIG. 1.—Southern corn rootworm: Larva or worm, side view. About $4\frac{1}{2}$ times natural size.

Although this rootworm sometimes damages the corn crop in the more northerly sections of the Middle West, it is not there consid-

¹ *Diabrotica duodecimpunctata* Fab.; order Coleoptera, family Chrysomelidae.

ered a serious corn pest. A closely allied insect, the western corn rootworm,² takes its place as an enemy of corn in these regions.

The southern corn rootworm is more commonly known as the "budworm"; in fact, few farmers know it under the former name. It is sometimes termed "drillworm." These names are more or less descriptive of the injury done to the plant by the worms. The adult, or parent, is known as the 12-spotted cucumber beetle, from the fact that it has 12 black spots on its back and is often a serious enemy to cucumbers and allied plants.

GEOGRAPHICAL RANGE OF THIS AND RELATED ROOTWORMS.

The southern corn rootworm has a very wide distribution. It is found throughout the greater part of the United States from Maine

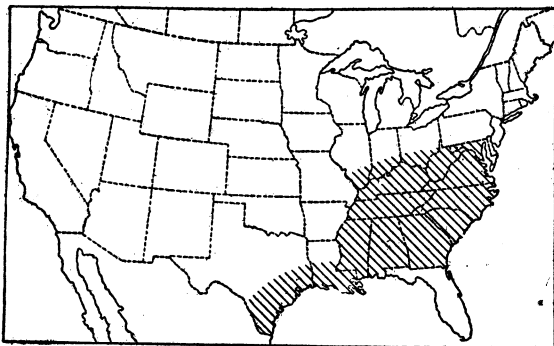


FIG. 2.—Map showing, by shaded area, region where corn is most seriously injured by the southern corn rootworm.

to Florida, and from the Atlantic coast to the Rocky Mountains. It occurs also in Mexico and Canada. It is not recognized, however, as a serious enemy of Indian corn north of Maryland and the southern parts of Ohio, Indiana, and Illinois, south of Georgia, or west of

the Mississippi River, with the exception of parts of southeastern Texas and southern Louisiana. (Fig. 2.)

The western corn rootworm³ occurs from Maine to the Gulf of Mexico and westward to Minnesota, South Dakota, and New Mexico.

In the States bordering the Pacific occurs a closely allied species.⁴ This western rootworm is often injurious to various cultivated crops. In southern Texas there is still another species, the belted cucumber beetle,⁵ which sometimes does practically as much damage to corn in that region as the southern corn rootworm.

WHEN SERIOUS INFESTATIONS MAY BE EXPECTED.

Serious infestations of the rootworm may be expected during seasons of abundant rainfall and cool weather, conditions conducive to the development of this insect. Corn in lowlands is more seriously

² *Diabrotica longicornis* Say.

³ *Diabrotica longicornis* Say.

⁴ *Diabrotica soror* LeConte.

⁵ *Diabrotica balteata* LeConte.

affected than that in uplands, as this insect prefers to breed in moist soil. Thus it is only during years of heavy infestation that corn in uplands is subject to serious damage.

INJURY TO CORN BY THE ROOTWORM.

The worm or larva stage (fig. 1) of this insect is the one most injurious to corn. As the name "corn rootworm" would indicate, it feeds on the roots of corn, but it does not confine its injuries to the roots; indeed, the greatest damage to young corn is that done by the worms in drilling a small hole into the stem directly above the first circle of roots (see title-page illustration) and feeding on the interior, boring out the crown and killing the bud. Plants affected in this way break off at the injured point when an attempt is made to pull them. In older corn the worms injure the roots almost exclusively.

HOW INJURY TO CORN BY THE ROOTWORM CAN BE RECOGNIZED.

When young corn has been damaged by this insect the fact can be easily detected. The bud leaves of injured plants, having been cut off from the main plant, dry up and die (fig. 3), while the rest of the plant retains its original color for a time. Subsequently the whole plant dies if injured badly. *Badly injured plants occasionally give rise to suckers which may produce ears, but these are usually of a poor quality.* It is on account of the peculiar injury to the bud that the insect is often called the "budworm."



FIG. 3.—Corn plant showing injury by southern corn rootworm to growing point or "bud."

Older plants, when attacked, present a sickly, yellowish, and dwarfed appearance due to the fact that the worms are feeding on the roots. Very often such plants also exhibit a number of suckers which are either sterile or may produce grain of an inferior quality.

DEVELOPMENT.

The southern corn rootworm has four distinct stages through which it passes in development. The first is the egg, the second the worm or larva, the third the pupa or resting stage, and the fourth the adult, parent, or beetle.

EGG STAGE.

The egg (fig. 4) is oval and about the size of a large pinhead. It is dull yellow when freshly laid, but later turns a deeper yellow. Its surface is covered with extremely small, shallow pits which in outline resemble a six-sided figure. Eggs are deposited by the female beetle in contact with or near the corn plants, slightly below the surface of the ground. Their number varies greatly. More than 500 may be laid by one individual and as many as 100 in one day. Eggs usually are deposited early in the evening. Sometimes, however, the female may deposit eggs in the daytime, even at midday. The eggs hatch in about three weeks

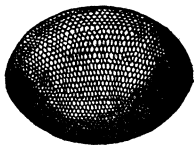


FIG. 4.—Southern corn rootworm: Egg, greatly enlarged.

in very early spring, and in from six to eight days in midsummer. The length of the egg period depends upon the prevailing temperature conditions.

WORM OR LARVA STAGE AND LARVAL FOOD PLANTS.

The worm or larva (fig. 1) when hatched from the egg is slender and yellowish white with a dark-brown head and a dark patch on the top of the last body segment. It is active at this stage of growth and so small that it is scarcely perceptible to the unaided eye. The full-grown larva usually is deep yellow. The head and patch on the last body segment are somewhat darker than in the newly hatched larva. The mature larva tapers toward the head end, the last few segments of the body being much wider than the head, which makes them appear as if swollen. The worm stage lasts from three to four weeks. Occasionally, however, the insect may live in this stage from five to six weeks. In the process of development the larva sheds its outer coat twice. This shedding of the skin is known as molting, and is necessary to enable the larva to increase in size.

Upon examining infested corn one may find the worms in their tunnels or among the roots, though sometimes they are found some

distance away from the injured plants, probably migrating to other corn plants in the same row. Usually only one larva is found at one plant. Sometimes two may be found, but this is the exception.

In addition to corn, the larvæ of this species are known to feed and live on the roots of Johnson grass, Southern chess,⁶ wheat, millet, rye, young oats, and alfalfa.

PUPA OR RESTING STAGE.

After the worm is full-grown it enters the ground to a depth varying from a few inches to a half foot or more, depending upon the texture of the soil. It then makes a cell somewhat oval in outline and smooths it very evenly on the inside. Presently it begins to shorten, and after a few days it sheds its skin and passes into the pupa or resting stage.

What the pupa is like is shown by figure 5. In this stage the insect can not move from place to place and is not destructive. It never leaves its cell. The only part capable of movement is the tip of the abdomen, which is moved about violently when the pupa is disturbed. The pupa is soft, yellowish, and about one-fourth of an inch long. It is a little longer than the width of its broadest part and has two very conspicuous spines at the tip of the abdomen.

The pupa stage lasts from 6 to 8 days in summer, and from 10 to 13 days in spring and fall. At the end of this period the 12-spotted beetle or adult comes forth and works its way through the soil to the surface of the ground.

ADULT OR BEETLE STAGE AND FOOD HABITS OF THE BEETLE.

The adult or beetle (fig. 6) is about one-fourth inch long, yellowish-green, with a black head and legs and, as previously stated, with 12 black spots on the back. These spots are irregular in outline and generally somewhat separated.

The beetle is very active during warm weather and can be captured only with difficulty. When feeding, if danger threatens, it falls to the ground and crawls away under rubbish or hides under the foliage of smaller plants. During cool weather it becomes less active, and when the temperature is near freezing it scarcely moves, even when disturbed.

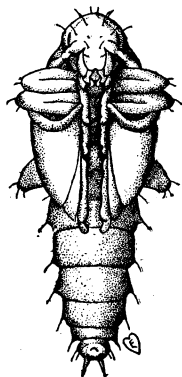


FIG. 5. — Southern corn rootworm: Pupa or resting stage. About eight times natural size.

⁶ *Bromus unioloides*.

In this stage the insect often does considerable damage to young corn by cutting off the bud leaves, although such plants usually recover. The adult or beetle is more injurious to certain truck crops than to corn, especially squashes, cucumbers, etc., and on this account is known as the 12-spotted cucumber beetle. Injury to these plants consists of numerous small holes in the leaves, and if plants are small and have only a few leaves much harm is done.

In relation to corn the beetle stage is important as being the egg-laying period of the insect, for the female, after having mated, places her eggs in the soil near the corn plants.

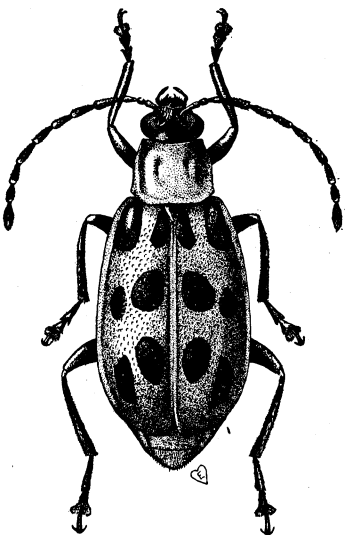


FIG. 6.—Southern corn rootworm:
Adult or beetle. About eight times
natural size.

HOW THE INSECT PASSES THE WINTER.

The southern corn rootworm passes the winter in the beetle stage, except possibly in southern Florida and Texas. In northerly regions the beetles go into hibernation late in the fall; that is, they crawl under rubbish and to other places that afford them protection from the cold and remain in an inactive condition during the winter. With the return of warm weather they again become active. In the more southern States, where temperatures are mild, they do not hibernate in the winter, but during cool days and nights hide under rubbish, among dead grasses, or under low-

leaved plants, and resume activity when the weather again becomes warm. There are some native plants which remain green throughout the winter in the South, and beetles have been found feeding on them, as well as on alfalfa, rye, oats, and other field crops, during warm days in midwinter.

NUMBER OF GENERATIONS.

This insect has two generations annually in the region of Columbia, S. C., and it is very likely that it has no more than two anywhere in the United States. Even though the adults of the second generation appear in sufficient time to reproduce the same year, they refrain from so doing until the following spring. The beetles of the second generation do not mate until the approach of fall or cooler weather.

Serious injury to young corn is largely done by the larvæ of the first generation of the year.

NATURAL ENEMIES.

NATIVE BIRDS.

A number of our native birds prey upon the adults, or beetles, of the southern corn rootworm. Some of the common ones are the bobwhite, red-headed woodpecker, nighthawk, cardinal, kingbird, and phoebe. Of these birds the bobwhite deserves special mention. As many as 12 of the beetles have been found in the stomach of one bobwhite.

INSECTS.

The southern corn rootworm has only a few insect enemies, the chief one being a two-winged fly⁷ (fig. 7) which attacks it in the beetle stage. This fly places a maggot, or larva, in the abdomen of the beetle, and the maggot feeds on the

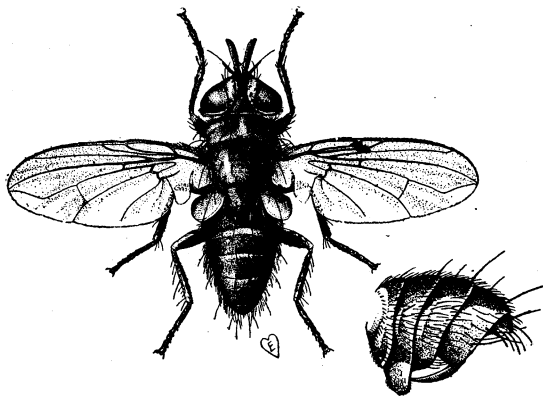


FIG. 7.—A fly enemy of the southern corn rootworm. At the right is shown the piercer by means of which the fly deposits a maggot within the adult or beetle of the rootworm. Fly about eight times natural size.

vital organs of the host and finally kills it. After the death of the beetle the parasite larva, being full-grown, enters the ground and forms a tough, leathery case in which it passes into the next or pupa stage. This case, termed puparium, is dark and covered with needle-like spines. From the puparium there emerges in due time the adult, or fly, which starts the cycle again. This parasite is not very common and thus far has not played a very great rôle in the destruction of the pest.

PREVENTIVE AND OTHER CONTROL MEASURES.

Various methods, when diligently and thoroughly employed, will aid greatly in preventing injury to corn by the southern corn rootworm. The most important of these methods is timely planting.

⁷ *Celatoria diabroticae* Shimer.

TIMELY PLANTING FOR LOWLANDS SUBJECT TO INFESTATION.⁸

The time at which the corn is planted affects to a large extent its likelihood of escaping rootworm damage. There is a period during which the worms are very active and do much damage. This period varies somewhat with the latitude and to a less extent with the altitude. It is earlier in the extreme South than in the more northerly

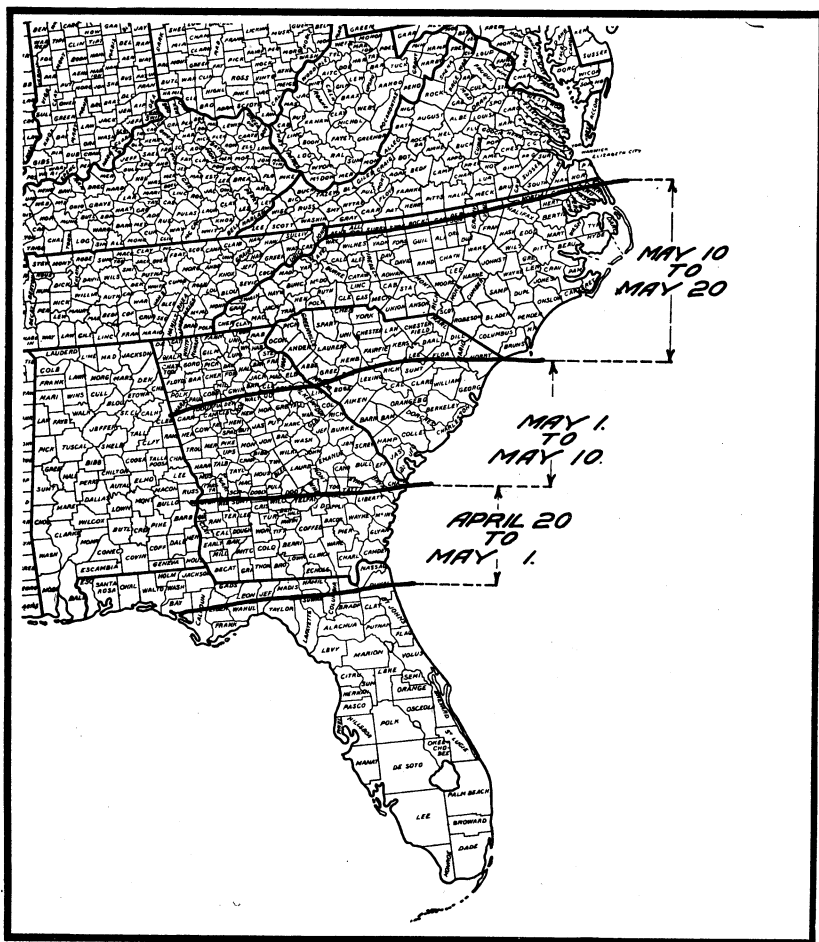


Fig. 8.—Periods during which corn should be planted in order to escape injury from the Southern corn rootworm.

regions and slightly earlier in the lower than in the upper altitudes. The results of the investigations to determine the timely planting periods in infested lowlands of the Southeastern States show that the region may be divided into three belts or zones, each of which has a

⁸ In North Carolina the work upon which these recommendations are based was conducted in cooperation with Prof. Z. P. Metcalf, entomologist of the experiment station; in Florida, with Prof. J. R. Watson, State entomologist.

definite planting period. (See fig. 8.) The first or lower zone includes northern Florida and southern Georgia, and has a timely planting period extending from April 20 to May 1. The second or central zone includes central Georgia and the southern half of South Carolina, and here the safe planting period is from May 1 to May 10. The third or upper zone includes northern Georgia, the northern half of South Carolina, and all of North Carolina. The safe planting period for this zone is from May 10 to May 20. Lowlands planted to corn in the three regions during the planting periods recommended will not be seriously infested by rootworms, and many of the plants that are infested under these conditions will recover. Corn planted in Georgia, South Carolina, and North Carolina during April usually suffers severe injury. Plantings made very early in the season occasionally escape damage. However, on account of the danger from frost it is not advisable to plant low grounds as early as this. Furthermore, it is seldom possible to make an early planting. The soil in the lowlands at this time of year is often too wet to permit plowing and a good preparation of the seed bed.

In each locality the safe planting periods naturally will vary somewhat from year to year, depending upon seasonal weather conditions. During exceptionally early seasons the period may be advanced somewhat, while during late seasons it should be delayed. Every farmer, however, by careful observations extending over a period of years, may discover at what date his low ground should be planted so as to minimize the ravages of this pest, taking into account, of course, other important factors in crop production.

BURNING OVER WASTE PLACES.

Large numbers of beetles are destroyed by burning over waste places, such as the borders and terraces of fields. This should be done in the winter and on cool days. Beetles at that time and on such days congregate in dead grasses, seeking protection from cold. The value of this measure is realized when one considers that the killing of one female in winter is as important as would be the destruction of from 400 to 600 worms in the spring.

CROP ROTATION.

Judicious crop rotation should be practiced wherever possible. It is not well to follow corn with corn. There are several crops that are not injured by these worms, the foremost of which is cotton. Some of the smaller grains are only slightly damaged and can, therefore, be used to good advantage in the rotation. If a corn crop follows one of the smaller grain crops the same year it will not be damaged by the rootworm, because of lateness of planting.

THICK PLANTING.

It is a common practice among some of the planters in the south-eastern States who are acquainted with rootworm injury to plant corn thicker in the lowlands than in the uplands. Double the number of grains are dropped in low ground. This offers twice the chance of securing a stand and is to be recommended especially for fields which consist partly of low ground. The upland in such cases may be planted in the regular way. In lowlands of large area this measure loses its value, for if corn is planted thickly some thinning may be necessary and this may mean a loss of labor, time, and money; under such conditions timely planting periods should be observed as recommended.

ENRICHING THE SOIL.

Soil rich in plant food will produce plants that are more hardy, healthy, and capable of resisting insect attack than soil which is not so supplied. Plants injured by the "budworms" sometimes recover, and the chances are that a larger percentage will do so in rich than in poor soil. Legumes should rank high in the rotation. They will add to the soil the much desired humus as well as store in the soil the valuable nitrogen extracted by these plants from the air.

It has been found that lowlands supplied abundantly with animal fertilizers are more seriously affected by these worms than those not so treated. It is well to use commercial fertilizers in such cases. This does not, as believed by some, repel the insects, but affords a less favorable breeding place.

SUMMARY OF CONTROL MEASURES.

(1) To prevent serious injury to corn by the southern corn rootworm, lowlands in southern Georgia and western Florida should not be planted before April 20 to May 1; in central Georgia and the southern half of South Carolina, not before May 1 to May 10; in northern Georgia, the northern half of South Carolina, and all of North Carolina, not before May 10 to May 20. If possible no corn should be planted in the lowlands in this region during the month of April.

(2) Destroy beetles by burning over waste places in winter.

(3) Practice rotation of crops. Do not follow corn with corn. Follow rotation as recommended by your State Experiment Station or by the United States Department of Agriculture.

(4) Plant low places in fields twice as thick as the uplands. Thin out later if necessary.

(5) Enrich the soil. Raise leguminous crops; these add humus and nitrogen to the soil.